SYNOPSIS

Plant Extract Mediated EcologicaL Synthesis of Encapsulated Copper and Silver Nanoparticles for Biological Application

Submitted by

Nishat Bhatia

R. No H-13057

Supervised By

Dr. Rahul Sharma

Assistant Professor

Session 2018-19

DEPARTMENT OF CHEMISTRY
SCHOOL OF BASIC AND APPLIED SCIENCES
CAREER POINT UNIVERSITY
HAMIRPUR (H.P.)-176041

1. Introduction

Particles within the size range of 1-100 nm are considered as nanoparticles (NPs) [1]. Modern nanotechnology was the brain child of Richard Feynman, the 1965 Nobel Prize Laureate in physics. The ideas and concepts behind nanoscience and nanotechnology started with a talk entitled "There's Plenty of Room at the Bottom" by physicist Richard Feynman at an American Physical Society meeting at the California Institute of Technology (Caltech) on December 29, 1959, long before the term nanotechnology was used. Humans previously exploited the reinforcement of ceramic matrixes by counting natural asbestos nanofibers more than 4,500 years ago [2]. The earliest evidence of the use and applications of nanotechnology can be traced back to carbon nanotubes, cementite nanowires found in the microstructure of wootz steel manufactured in ancient India from the time period of 600 BC and distributed globally[3].The introduction of nanotechnology in several aspects of physics, chemistry and biology was given by Prof. Norio Taniguchi.

In 2007, Pokropivny and Skorokhod finished a new scheme of classification for NPs which included the recently developed composites such as 0D, 1D, 2D and 3D NMs [4].The synthesis of metallic NPs via chemical methods dates back to the 14th and 13th century BC when Egyptians and Mesopotamians started making glass using metals, which can be stated as the foundation of the metallic nanoparticle about 1814 nanotechnology-based purchaser products that are commercially offered in over 20 countries [6].

1.1 Nanotechnology

This techonology has various applications in engineering, agriculture, clothing, cosmetics, food processing, electronics Nanoparticles (NPs) have wide range of tenders in areas such as health care, cosmetics, food and feed, environmental health, mechanics, optics, biomedical sciences, chemical industries, electronics, planetary industries, drug-gene delivery, energy science, optoelectronics, catalysis, single electron transistors, light emitters, nonlinear optical devices, and photo-electrochemical applications [7-12].

1.2 Medicinal chemistry and nanoparticles

Nanomedicine is the therapeutic application of nanotechnology [14]. Nanotechnology has provided the opportunity of delivering drugs to specific cells using Nano particles [15].

The overall drug consumption and side-effects may be dropped expressively by depositing the active agent in the morbid region only and in no higher dose than wanted. Targeted drug delivery is intended to reduce the side effects of drugs with concomitant decreases in consumption and treatment expenses. Drug delivery focuses on maximizing bio-availability both at specific places in the body and over a period of time. This can potentially be achieved by molecular aiming by Nano-engineered devices [15-16].

1.3 Nanotechnology as green approach

The Green Nano series aims to advance development of hygienic technologies using nano-technology to lessen potential environmental and human health risks associated with the manu-facture and practice of nanotechnology products, and to boost replacement of prevailing products with new Nano products that are additional environmentally friendly throughout their life cycle [17].

1.4 Characteristic properties of nanoparticles

Particle size in nano range comprises great area of concern with respect to physical, biological and chemical characteristics. Scientific research on nanoparticles is penetrating as they have many possible applications in medicine, physics [18, 19] and optics, and electronics [20].The use of nanoparticles is firmly centered upon their shape and size [21].

1.4.1 Silver (Ag) NPs

Silver nanoparticles are nanoparticles of silver of stuck between 1 nm and 100 nm in size [22] with atomic no 47. Naturally befalling silver is composed of two constant isotopes, ^{107}Ag and ^{109}Ag, with ^{107}Ag being somewhat more abundant (51.8% natural abundance). This almost equal abundance is uncommon in the periodic table. The atomic weight is 107.8682(2) u. The antibacterial properties of Ag salts have been noticed meanwhile ancient times and Ag is currently used to control bacterial growth in a variety of applications, including dental work, tubes, and burn wounds [23-24]. Ag NPs have been used widely as anti-bacterial mediators in the health industry, food loading, textile varnishes and a number of environmental requests [25].

1.4.2 Copper (Cu) NPs

Copper is transition metal with atomic no 29. One of the original uses of copper nanoparticles was to color glass and ceramics during the ninth century in Mesopotamia [26]. Copper founded nanoparticles are orbicular blackish-brownish metallic nanoparticles with size ranges from 30 to 70 nanometers with high surface area frequently available in moreover pure, dispersed or carbon

coated form [27-28]. Copper nanoparticles are being given significant attention as of late due to their fascinating properties and potential applications in numerous areas of industry [29]. Copper oxide (CuO) nanoparticles were characterized and investigated with admiration to potential antimicrobial applications [30]. Copper nanoparticles have been used in the preparation of disinfectant for wastewater in lots of parts of the world [31]. Copper nanoparticles treated drugs are extensively used to undermine cancerous and tumorous cells [32] and along with Copper nanoparticles also known to yield fluorescence, causing dye deposit accretion thus making them suitable for bio-sensing and bio labeling [33-34].

1.5 Synthesis of nanoparticles

NPs have expanded significant interest because of their unique properties and proven applicability in varied areas such as medicine, catalysis, textile engineering, biotechnology, nano-bio technology, bio-engineering sciences, electronics, optics and water treatment also other available applications. These NPs have significant inhibitory possessions against microbial pathogens, and are broadly used as antimicrobial mediators in an assorted range of products. Different physical and chemical processes are presently broadly used to synthesize metal nanoparticles, which permit one to attain particles with the looked-for characteristics [35-38]. Obviously, the synthesis of metal nanoparticles in plant extracts (plant biomasses), in spite of noticeable limitations, has a significant potential and a number of significant advantages relative to old-style methods of nanoparticle synthesis. The problem with most of the chemical and physical methods of nano production is that they are exceedingly expensive and also comprise the use of toxic, hazardous chemicals, which may place potential environmental and biological risks. The three major components elaborate in the preparation of nanoparticles using biological methods are the solvent medium for production, the environmentally friendly dropping agent, and a nontoxic stabilizing agent. The mounting need to develop environmentally friendly and economically practicable technologies for material synthesis led to the search for biomimetic methods of synthesis [39].

1.5.1 Biomimetic methods and plant selection

In the proposed work biological method for the synthesis of NPs has been chosen. The NPs shape, size and structure differs with these parameters, subsequently, selection of plant plays a crucial role [40]. So, in the present research work seed and root extract has been used for the synthesis of Cu and Ag NPs respectively for their various medicinal applications i.e. antimicrobial, ,antioxidant and anticancerous respectively.

1.5.1.1 *Duchsnea indica* (Indian mock berry)

*Duchesnea indica (*Figure *) (sometimes called *Potentilla indica*), known commonly by the name mock strawberry, Indian strawberry, or false strawberry and other names *Duchsnea fragi-formis, Fragaria indica , Potentilla indica* are flowering plants found in lower Himalaya regions. Whole plants displays anticoagulant, antiseptic, depurative activity and also used in the handling of abscesses, weeping eczema, ringworm, stomatitis and other ailments. The herbage of the plant has recognized antitumor activity [41]. The whole plant was used as an anticancer herb in outmoded Chinese medicine [42]. There are reports from China on the segregation of triterpenoids and additional biologically active complexes from *Duchesnea indica* [43].

1.5.1.2 *Potentilla astrosanguinea* (Dark Crimson Cinquefoil)

Potentilla can be herbaceous perennials, deciduous shrubs or annuals with palmately or pinnately divided leaves and solitary or clustered, saucer-shaped, 5-petalled flowers appearing over a long period of time. *Potentilla atrosanguinea* (Figure **) is a clump-forming perennial with three-lobed leaves sheltered in silky hairs. This plant is uncommonly found in Himalaya range especially high mountain ranges. Extracts from *Potentilla* species have been practical in traditional medicine and exhibit antioxidant, hypoglycemic, anti-inflammatory, antitumor and anti-ulcerogenic properties [44].

Duchsnea indica[*]

Potentilla astrosanguinea[**]

[*]Plant collected and image taken at Ghumarwin District Bilaspur (H.P*)*

[**]Plant collected and image taken at Parashar lake District Mandi (H.P)

2. Review of Literature

Although nanoparticles are connected with contemporary science, they have a long history. Nanoparticles were used by craftsperson as far back as Rome in the fourth century in the famous Lycurgus cup made of dichroic glass as well as the 9^{th} century in Mesopotamia for producing a glittering effect on the surface of pots. Lots of researchers have done research in the preparation of metal NPs along with their application [44-45]. Chemical methods mainly involve reduction through chemicals by retaining solvo thermal or hydrothermal technique, sol-gel method, polyol method, etc. [46-47]. However, chemical reactions are dangerous, costly, overriding high energy and difficult to scale up.

Another is a modest one-step process, Tollens method, has been used for synthesis of silver NPs with a measured size. This green synthesis technique involves reduction of Ag $(NH_3)_2^+$ (as Tollens reagent) by an aldehyde [48]. Microwave-assisted synthesis is a hopeful method for synthesis of silver NPs. Microwave heating is improved than a conventional oil bath when it comes to dependably yielding nano structures with smaller sizes, narrower size distributions, and an advanced degree of crystallization [49].

At the present time, there is a growing need to develop eco-friendly progressions, which do not use toxic chemicals in the synthesis conventions. Green synthesis as a biological approaches include mixed-valence polyoxometalates, polysaccharides, Tollens, biological, and irradiation technique which have compensations over conventional methods involving chemical mediators associated with environmental toxicity. Selection of solvent medium and selection of eco-friendly nontoxic reducing and stabilizing agents are the most important issues which necessarily be considered in green synthesis of NPs. Here is a great need to create ecofriendly and economically practicable technologies for material synthesis led to the search for biomimetic methods of synthesis [39]. So, biological method is simple easy and cut-rate method for the formation of NPs [50].

2.1 Ag NPs

Silver NPs have added considerable interest because of their unique properties, and proven applicability in diverse areas such as medicine, catalysis, textile engineering, biotechnology, Nano-biotechnology, bio-engineering sciences, electronics, optics and water treatment. Different methods have been developed to obtain silver NPs of several shapes and sizes, including laser ablation, gamma irradiation, electron irradiation, chemical reduction, photochemical methods,

microwave processing, and thermal decomposition of silver oxalate in water and in ethylene glycol, and biological synthetic manner. In 2009, Bar et al. [51] has studied the green synthesis of silver nanoparticles using seed extract of *Jatropha curcas*. In 2014, Khalil et al. [52] synthesized silver nanoparticles by using olive leaf extract and studied its antibacterial activity. In 2015, Ajitha et al. [53] has studied antibacterial activity of silver nanoparticles *Lantana camara* leaf extract. In 2016, Salari et al. [54] studied sustainable synthesis of silver nanoparticles using macroalgae *Spirogyra varians* and analysis of their antibacterial activity.

In most cases, the chemical synthesis methods lead to some chemically noxious substances being absorbed on the surface and can hinder their usage in medical applications. In most cases, the chemical synthesis methods lead to some chemically toxicating substances being absorbed on the surface and can hinder their usage in medical applications [55]. Scientists Li S and Shen Y did synthesis of silver nanoparticles using *Capsicum annuum* [56]. Synthesis of NPs using plants extract is very cost effective and thus can be used as an economic and valuable substitute for the large-scale production of NPs [57].

2.2 Cu NPs

Copper nanoparticles received much attention due to its high electrical conductivity, high melting point, low electrochemical migration behavior and low cost. Top down (physical methods) and bottom up (chemical and biological) approaches accepted for the synthesis of copper nanoparticles are reported. Currently developed synthesis methods for copper nanoparticles include chemical reduction. In 2010, Li, Y. et al. [58] has studied the facile synthesis of leaf-like CuO nanoparticles and their application on glucose biosensor. In 2011, Lee et al. [59] studied the biological synthesis of copper nanoparticles using plant extracts for antioxidant and antibacterial activity. In 2014, M. Gopinath et al. [60] studied the synthesis of Copper nanoparticles from *Nerium oleander* Leaf aqueous extract and it's Antibacterial Activity. In 2015, Nasrollahzadeh et al. [61] synthesized CuO nanoparticles by aqueous extract of *Gundelia tournefortii* and evaluated their catalytic activity for the synthesis of N-mono substituted ureas and reduction of 4-nitrophenol. In 2017 Issaabadi et al. [62] synthesized copper nanoparticles supported on bentonite and investigated its catalytic activity. In 2018, Sharmila et al. [63] biogenically synthesized CuO nanoparticles using *Bauhinia tomentosa* leaves extract and studied their antibacterial and catalytic activity.

3. Research Gap Identification

However a variety of dissimilar methods have been developed to obtain NPs of various shapes and sizes of Ag and Cu NPs including laser ablation, gamma irradiation, electron irradiation, chemical reduction, photochemical methods, microwave processing, and thermal decomposition of silver oxalate in water and in ethylene glycol and biological synthetic method but the chief components tangled in the preparation of nanoparticles using biological approaches are the solvent medium for synthesis, the environmentally friendly reducing agent and a nontoxic stabilizing agent. Synthesis of NPs using plants extract is very cost effective and thus can be used as an economic and valuable alternative for the large-scale production of NPs [64]. So in addition to it, biologically synthesized NPs through plant extract for Anticancerous, antimicrobial and antioxidant applications need more too much attention.

4. Research Objectives

Based upon the previously discussed content my objectives would be focusing on

1. Green synthesis of Ag and Cu NPs by including the use of seeds extract of Indian mock berry (*Duchsnea indica*) and roots extract of wild berry i.e. (*Potentilla astrosanguinea*.).
2. Characterization of synthesized NPs by different characterization techniques like XRD, SEM, TEM, UV-Visible, etc.
3. Inquesting antibacterial and antioxidant activities of synthesized NPs.

5. Proposed Methodology

In the literature review lots of methods different physical and chemical methods for the synthesis of NPs have been conveyed [39, 45-49]. But keeping in mind the advantage of biological plant extract synthesis of NPs with reference to eco-friendliness and cost effectiveness. The current work would be performed by using the plant extract of plants *Duchsnea indiaca and Potentilla astrosanguinea* (seeds and roots) respectively as a green approach [39].

5.1 Material

2, 2 Diphenyl-1-picrylhydrazyl (DPPH), copper acetate, Whatman No.1 filter paper, silver nitrate, ethylene glycol, sodium hydroxide, potassium hydroxide and ethanol, *Duchsnea indica* and *Potentilla astrosanguinea* plant part and roots of these plants will be used.

5.2 Methods

5.2.1. Preparation of hydro-alcoholic plant extract of *Duchsnea indica*

10 g of the dried out roasted plant will be finely crushed and stirred with 1:1 ratio of 50 mL de-ionized water and 50 mL ethanol at 60 °C for 1 h and filtered through a Whattman filter paper No. 1 to get the extract. The filtrate further would be used as a reducing agent and also as a stabilizer. The flowchart illustrates the stepwise scheme adopted during the synthesis of the extract [40].

5.2.2. Synthesis of Silver Nanoparticles

The Ag NPs can synthesized using 0.02 M, 0.05 M, and 0.1 M silver nitrate solutions and hydro-alcoholic extract of plant of *Duchsnea indica* (volume of extract was kept constant for all the three dissimilar concentrations). Both the solutions would be mixed to initiate the reduction of $AgNO_3$ solution into Ag^+ ions. The mixture then to be stirred continuously for about 10 min on a magnetic stirrer and the solution would be further incubated at room temperature for 2 h. Color changes may be observed. Then after this the reduced mixture would be purified by repeated centrifugation at 4000 rpm for 5 min. and transferred to a clean dry beaker for further settlement of particles and repeated process of centrifugation would be carried out to purify Ag NPs. The sample so obtained needs to be dried and then may be stored for further characterizations [41].

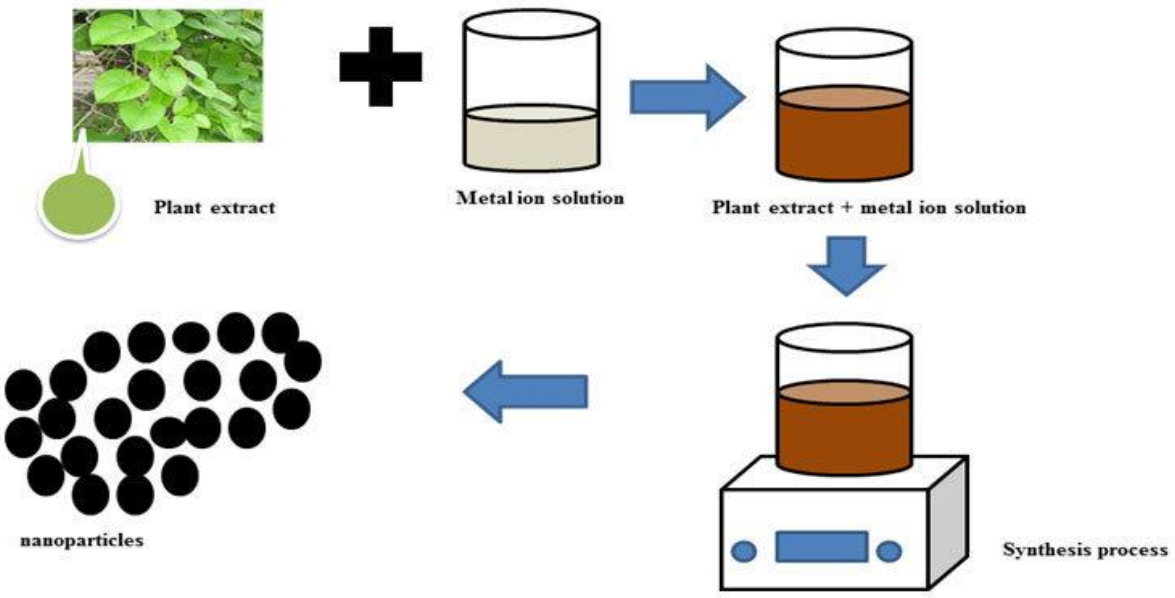
5.2.3 Preparation of root extract of *Potentilla astrosanguinea*

The vigorous and seasoned root firstly washed thoroughly. The epidermis of roots needs to be peeled off with the help of a scalpel and the pith should be separated with the help of forceps to get the cortex. 5g of cortex then is homogenized in a mortar and Pestle and suspended in 100 ml of distilled water. Then both the solutions then would be boiled up to 10 min at 110°C in a glass flask. The suspended mass then needs to be filtered out. The filtrate mainly obtained contains the bioactive components leached from the roots. This filtrate would be used as the extract for the preparation of Copper nanoparticles [42].

5.2.2.2. Synthesis of Copper Nanoparticles

In this experiment to the 10 ml of root extract, 100ml of 1 mM copper salt ($CuSO_4.5H_2O$) solution is added drop wise. Similarly, temperature in one plant extract and in another solution of copper sulphate were also maintained the same. The reaction mixtures along with controls were exposed to room temperature for 1 hr. under static condition the change in color may be noted in case of root extract. Thus, color change indicates reduction and reduced copper nanoparticles has been

obtained. Schematic illustration of synthesis mechanism of Cu NPs from plant root extracts and 1 Mm $CuSO_4$ [43].



Schematic diagram of Green Synthesis of NPs

5.3 Characterization of synthesized NPs

NPs are generally characterized by capitalizing their size, shape and surface area. A homogeneity in these properties consequence in the advancement in applications of NPs. The characterization will be done by using UV–Visible Spectroscopy, Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), X-ray Diffraction (XRD) and Energy Dispersive Spectroscopy (EDS), Fourier-Transform Infrared Spectroscopy (FTIR).

5.4 Application of NPs

Synthesized NPs will be studied for their antioxidant property. Antioxidants are compounds that prevent oxidation. DPPH is commonly on use chemical compound used to determine the antioxidant activities of various synthesized compounds [65].

Synthesized NPs will be studied for their antimicrobial activity by investigating their inhibition zone/area for the microbes [66-70].

6. Thesis Outline

CHAPTER 1 (Introduction):

This chapter will contain the brief introduction regarding NPs, biological methods, plants extract and NPs of transition metal.

CHAPTER 2 (Literature Review):

This chapter will deal with intense literature survey of synthesis and applications of Ag and Cu NPs.

CHAPTER 3 (Materials and Methods):

It includes the experimental details on material used, biological methods of synthesis, characterization techniques and applications of synthesized NPs.

CHAPTER 4 (Results and Discussion):

This chapter will include detailed discussion on results of present work which includes the key points and various aspects of synthesis, characterization and applications of transition metal (Cu and Ag) NPs.

CHAPTER 5 (Summary and Conclusions):

This chapter will summarize and correlate all the above mentioned chapters in lucid manner.

Research Plan Schedule

Research Activity	Progress in Months											
	3	**6**	**9**	**12**	**15**	**18**	**21**	**24**	**27**	**30**	**33**	**36**
Course work and extensive literature survey or design of work	Aug 2018 to Dec 2018											
Research gap identification, development methodology and submission of synopsis			Jan 2019 to July 2019									
Experimental Work and Publications					August 2019 to December 2020							
Thesis writing and Publications									Dec 2020 to Jul 2021			

References

1. Chung, M.; Park, I.; Seunghyun, K.; Thiruvengadam, M.; Rajakumar, G. Plant-Mediated Synthesis of Silver Nanoparticles: Their Characteristic Properties and Therapeutic Applications. *Nanoscale Res. Lett*. **2016**, *11*, 1-14.
2. Heiligtag, F.J.; Niederberger, M. The fascinating world of nanoparticle. *Nanotechnol*. **2013,** *16*, 262-271.
3. Sanderson, K. Sharpest cut from nanotube sword. *J. Nanotechnol.* **2006,** *444***,** 11-15.
4. Pokropivny, V.; Skorokhod, V. Classification of nanostructures by dimensionality and concept of surface forms engineering in nanomaterial science. *Mater. Sci. Eng.* **2007,** *27*, 990-993.
5. Schaming, D.; Remita, H. Nanotechnology from the ancient time to now a days. *Found Chem.* **2015,** *17*, 187-205.
6. Vance, M.E.; Kuiken, T.; Vejerano, E.P.; McGinnis, S.P.; Hochella, M.F.J.; Rejeski, D.; Hull, M.S.; Beilstein. *J. Nanotechnol*. **2015,** *6*, 1769-1780.
7. Colvin, V.L.; Schlamp, M.C.; Alivisatos, A. Light emitting diodes made from cadmium selenide nanocrystals and a semiconducting polymer. *Int. J. Science*. **1994,** *370*, 354-357.
8. Wang, Y.; Herron, N. Nanometer-sized semiconductor clusters: materials synthesis, quantum size effects, and photophysical properties. *J .Phys .Chem*. **1991,** *95*, 525-532.
9. Schmid, G. Large clusters and colloids. Metals in the embryonic state. *Chem. Rev*. **1992,** *92*, 1709-1027.
10. Hoffman, A.J.; Mills, G.; Yee, H.; Hoffmann, M. Q-sized cadmium sulfide synthesis, characterization, and efficiency of photoinitiation of polymerization of several vinylic monomers. *J. Phys. Chem*. **1992,** *96*, 5546-5552.
11. Hamilton, J.F.; Baetzold, R. Catalysis by Small Metal Clusters. *Int.J.Sci.* **1979,** *205*, 1213-1220.
12. Mansur, H.S.; Grieser, F.; Marychurch, M.S.; Biggs, S.; Urquhart, R.S.; Furlong, D. Photoelectrochemical properties of 'q-state' Cd particles in archaic acid langmuir-blodgett films. *J. Chem. Soc. Faraday. Trans*. **1995**, *91*, 665-67.
13. Freitas, R.A.; Austin, T.X. Nanomedicine Basic Capabilities. *Nano. Med.* **2007**, *8*, 374-399.
14. Ranganathan, R.; Madanmohan, S.; Keralan, A.; Baskar, G.; Krishnamoorthy, Y.R.; Santosham, R.; Ponraju, D.; Rayala, S.K. Venkatraman, G. Nanomedicines towards development of patient-

friendly drug-delivery systems for oncological applications. *Int. J. Nano. Med.* **2012,** *43*, 1043-1060.

15. LaVan, D.A.; Mc.Guire, T.; Langer, R. Small-scale systems for in vivo drug delivery. *Nat. Biotech.* **2003**, *21*, 118-491.
16. Cavalcanti, A.; Shirinzadeh, B.; Freitas, R.A.; Hogg, T. Nanorobot Hardware Architecture for Medical Defense. *Sen. Sci.* **2008,** *8*, 2932-2958.
17. Radhey, M.; Bachhav, I.; Suvarna, N.; Deore. Environment and Green Nanotechnology. *Int. J. Sci*. **2013,** *4*, 2319-7064.
18. Hubler, A.; Osuagwu, O. Digital quantum batteries Energy and information storage in Nano vacuum tube arrays. *Wiley*. *Int. Sci*. **2010,** *20*, 306-310**.**
19. Taylor, R.; Coulombe, S.; Otanicar, T.; Phelan, P.; Gunawan, A.; Wei, R.; Gary, P.; Ravi, T. Small particles, A review of the diverse applications of nanofluids .*Int. J. Phys*. **2013**, *113*, 11301–11319.
20. Gawande, M.B.; Goswami, A.; Felpin, F.X.; Asefa, T.; Huang, X.; Silva, R.; Zou, X.; Zboril, R.; Varma R.S. Cu and Cu-Based Nanoparticles, Synthesis and Applications in Catalysis. *Chem. Rev.* **2016,** *116*, 3722-3811.
21. Graf, A.; Christina, V.; L.J.; Imhof, Y.; Blaaderen, V.A. A General Method to Coat Colloidal Particles with Silica. *Langmuir*. **2003,** *19*, 6693-6700.
22. Silver, S.; Phung, L.T. Bacterial heavy metal resistance. *Annu. Rev. Microbiol*. **1996,** *50*, 753-789.
23. Catauro, M.; Raucci, M.G.; de Gaetano, F.; Marotta, A. Antibacterial and bioactive silver-containing Na_2O and CaO $2SiO_2$ glass prepared by sol-gel method. *J. Mat. Sci*. **2004,** *15*, 831-837.
24. Crabtree, J.H.; Burchette, R.J.; Siddiqi, R.A.; Huen, I.T.; Handott, L.L.; Fishman, A. The efficacy of silver-ion implanted catheters in reducing peritoneal dialysis-related infections. *Perit. Dial. Int.* **2003,** *88*, 556-568.
25. Travan, A., Marsich, E., Donati, I., Paoletti, S. 2012. Silver Nanocomposites and Their Biomedical Applications. *Eur. Chem. Bull*. **2012**, *3*, 81-137.
26. Khan, F.A. Biotechnology Fundamentals *Nano. Biotech.* **2011**, 709, 10-24.
27. Dhas, N.A. Synthesis, characterization, and properties of metallic copper nanoparticles. *Mat. Chem*. **1998,** *10*, 121-145.
28. Park, B.K.; Jeong, S.; Kim, D.; Moon, J.; Lim, S.; Kim, J.S. Synthesis and size control of monodisperse copper nanoparticles by polyol method. *J. Int .Colloid. Sci.* **2007,** 311, 417-424.

29. Youngil, J.; Junrak, C.; Kwi, L.; Nathan, E.; Donghoon, K. Large-scale synthesis of copper nanoparticles by chemically controlled reduction for applications of inkjet-printed electronics. *Nanotech.* **2008,** *8*, 113-115.
30. Ren, G.; Hu, D.; Cheng, E.; W.C.; Vargas-Reus, M.A.; Reip, P.; Allaker, R.P. Synthesis of copper nanoparticles by thermal decomposition and their antimicrobial properties. *J. Nanomat.* **2009,** *1155*, 1-5.
31. Das, R.; Ali, M.E.; Hamid, S.B.A.; Ramakrishna, S.; Chowdhury, Z.Z. Carbon nanotube membranes for water purification with bright future in water desalination. *Desalination. J. Nanotech .Col*. **2014,** *336*, 97-109.
32. Li, Y. Copper sulfide nanoparticles for photo thermal ablation of tumor cells. *Nanomed*. **2010**, *5*, 44-56.
33. Gouanve, F. Fluorescence Quenching upon Binding of Copper Ions in Dye-Doped and Ligand-Capped Polymer Nanoparticles. *Adv. Fun. Mat*. **2007,** *17*, 2746-2756.
34. Chen, J. Random double stranded DNA-templated formation of copper nanoparticles as novel fluorescence probes for label-free lead ions detection. *Chem. Comm.* **2012,** 6, 7-48.
35. Fendler, J.H. Nanoparticles and nanostructured films their Preparation, characterization and applications. **1998,** *2*, 463-468.
36. Shanmuga, P.; Vasantha,V.S.; Jeyasundari, J.; Brightson, A.J. Synthesis of plant-mediated silver nanoparticles using *Ficus microcarpa* leaf extract and evaluation of their antibacterial activities. *Chem. Lett.* **2003,** *32*, 1114-1115.
37. Kundu, S.; Maheshwari, V.; Saraf, R. Polyelectrolyte mediated scalable synthesis of highly stable silver nanocubes in less than a minute using microwave irradiation. *Nanotech.* **2008,** 6, 65-604.
38. Okitsu, K.; Mizukoshi, Y.; Yamamoto, T.A.; Maeda, Y.; Nagata Y. *Mater. Lett.* **2007,** *61*, 3429-3431.,
39. Kalishwaralal, K.; Deepak, V.; Ramkumarpandian, S.; Nellaiah, H.; Sangiliyandi, G. Extracellular biosynthesis of silver nanoparticles by the culture supernatant of Bacillus licheniformis. *Mater. Lett*. **2008,** *62*, 4411-4413.
40. Rostami-Vartooni, A.; Nasrollahzadeh, M.; Alizadeh, M. Green synthesis of seashell supported silver nanoparticles using *Bunium persicum* seeds extract: Application of the particles for catalytic reduction of organic dyes. *J. Colloid and Interface Sci.* **2016,** *470*, 268-275.

41. Bar, H.; Bhui, D.K.; Sahoo, G.P.; Sarkar, P.; Pyne, S.; Misra, A. Green synthesis of silver nanoparticles using seed extract of *Jatropha curcas*. Colloids and Surfaces A: *Physichem Engr. Aspects*. **2009,** *348*, 212-216.
42. Laloo, D.; Prasad, S.K.; Krishnamurthy, S.; Hemalatha, S. Gastroprotective activity of ethanolic root extract of Potentilla fulgens Wall. Ex. Hook. *J. Ethnopham,* **2013**, *146*, 505-514.
43. Černík, M.; Thekkaepadil, V.V. Green synthesis of copper oxide nanoparticles using gum karaya as a biotemplate and their antibacterial application. *Int. J. Nanomed*. **2013**, 8, 889.
44. Makarov, V.V.; Love, A.J.; Sinitsyna, O.V.; Makarova, S.S.; Yaminsky, I.V.; Taliansky, M.E.; Kalinina, N.O. Green Nanotechnologies: Synthesis of Metal Nanoparticles Using Plants. *Acta. Nat*. **2014,** *6*, 35-44.
45. Liang, Y.; Yang, J.; Yaoxue, X. Tanshinones Sources, Pharmacokinetics and Anti-Cancer Activities. *Int. J. Mol. Sci*. **1996,** *31*, 841-844.
46. Peng, J.; Lu, Y.; Chen, D.; Zhongcaoyao. Copper-Catalyzed Intramolecular C-H Oxidation/Acylation of Formyl- N- arylformamides leading to Indoline-2, 3-diones. *J. Am. Chem. Soc*. **1995,** *26*, 132-339.
47. Rahn, L.I.; Kim, Y.H. Studies on the antitumor activity of *Duchesnea indica* Herba. *Arch. Pharm. Res*. **1986,** *9*, 1-4.
48. Wang, S.S.; Wang, D.M.; Pu, W.J.; Li, D.W. Phytochemical profiles, antioxidant and antimicrobial activities of three *Potentilla Sp. Altern Med.* **2013,** *19*, 13-321.
49. Schaming, D.; Remita, H. Nanotechnology from the Ancient Time to Nowadays. *Found. Chem.* **2015,** *17*, 187-205.
50. Zhang, J.; Sun, L.; Yin, J.; Su, H.; Liao, C.; Yan, C. Control of ZnO Morphology via a Simple Solution Route. *Chem. Mater*. **2002**, *14*, 4172-4177.
51. Bar, H.; Bhui, D.K.; Sahoo, G.P.; Sarkar, P.; Pyne, S.; Misra, A. Green synthesis of silver nanoparticles using *Jatropha curcas* seed extract. *Physichem. Engr Asp*. **2009**, *348*, 212-216.
52. Khalil, M.; Ismail, E.; El-Baghdadi.; Mohamed, D. Green synthesis of silver nanoparticles using olive leaf extract and its antibacterial activity. *Ar. J. Chem.* **2014,** *7*, 1131-1139.
53. Ajitha, B.; Ashok K.R.; Sreedhara, R. Green synthesis and characterization of silver nanoparticles using *Lantana camara* leaf extract. *Mat. Sci. Eng.* **2015,** *49*, 373-381.

54. Salari, Z.; Danafar, F.; Dabaghi, S.; Ataei, S.A. Sustainable synthesis of silver nanoparticles using macroalgae *Spirogyra varians* and analysis of their antibacterial activity. *J. Saudi. Chem. Soc*. **2016,** *20,* 459-464.
55. Akhavan, O.; Tohidi, H.; Moshfegh, A.Z. Synthesis and electrochromic study of sol-gel cuprous oxide nanoparticles accumulated on silica thin film. *Arch. Pharm. Res*. **2009,** *517,* 6700-6706.
56. Charitidis, C.A.; Georgiou, P.; Koklioti, M.A.; Trompeta, A.F.; Markakis, V. Manufacturing nanomaterials from Research to Industry. *Manuf. Rev.* **2014,** *1*, 1-19.
57. Yin, Y.; Li, Z.; Y.; Zhong, Z.; Gates, B.; Venkateswaran, S. Synthesis and characterization of stable aqueous dispersions of silver nanoparticles through the Tollens process. *J Mater Chem*. **1998,** *12*, 522-527.
58. Li, Y.; Wei, Y.; Shi, G.; Xian, Y.; Jin, L. Facile synthesis of leaf-like CuO nanoparticles from *Cocoa* leaves. *Found. Chem.* **2010**, *23,* 497-502.
59. Lee, H.J.; Lee, G.; Jang, N.R.; Yun, J.H.; Song, J.Y.; Kim, B.S. Biological synthesis of copper nanoparticles using plant extracts. *Nanotechnol*, **2011**, *1,* 371-374.
60. Gopinath, M.; Subbaiya, R.; Masilamani, M.; Selvam, R.; Suresh, D. Synthesis of copper nanoparticles from *Nerium oleander* leaf aqueous extract and its antibacterial activity. *Int. J. Curr. Microbiol. App. Sci.* **2014,** *3,* 814-818.
61. Nasrollahzadeh, M.; Maham, M.; Mohammad, S. Green synthesis of CuO nanoparticles by aqueous extract of *Gundelia tournefortii* and evaluation of their catalytic activity for the synthesis of N-mono substituted ureas and reduction of 4-nitrophenol. *J. Coll. Inter. Sci.* **2015,** *455,* 245-253.
62. Issaabadi, Z.; Nasrollahzadeh, M.; Sajadi, S.M. Green synthesis of the copper nanoparticles supported on bentonite and investigation of its catalytic activity. *J. Cleaner. Prod*. **2017,** *142*, 3584-3591.
63. Sharmila, G.; Thirumarimurugan, M.; Sivakumar, V.M. Optical, catalytic and antibacterial properties of phytofabricated CuO nanoparticles using Tecoma castanifolia leaf extract. *Int. J. Light. Electron. Optics*. **2016**, *127*, 7822-7828.
64. Dobrucka, R.; Dugaszewska, J. Biosynthesis and Antibacterial activity of ZnO Nanoparticles using *Trifolium Pratense* Flower Extract. *Saudi J. Biol. Sci*. **2016,** *23*, 517-523.
65. Parashar, U.K.; Saxena, S.P.; Srivastava, A. Bioinspired synthesis of silver nanoparticles. *Nanomat. Biostruct.* **2009,** *4*, 159-166.

66. Li, S.; Shen, Y.; Xie, A.; Yu, X.; Qiu, L.; Zhang, L. Green synthesis of silver nanoparticles using *Capsicum annuum* leaf Extract. *Green Chem.* **2007,** *9*, 852-858.
67. Iravani, S. Green synthesis of metal nanoparticles using plants. *Green Chem.* **2011,** 13, 2638-2650.
68. Dang, T.M.D.; Le, T.T.T.; Fribourg-Blanc, E.; Dang, M.C. Synthesis and optical properties of copper nanoparticles prepared by a chemical reduction method. *Nat. Sci Nanosci. Nanotech.* **2011,** *2*, 1-5.
69. Banerjee, P.; Satapathy, M.; Mukhopahayay, A.; Das, P. Leaf Extract Mediated Green Synthesis of Silver Nanoparticles from Widely available Indian Plants: Synthesis, Characterization, Antimicrobial Property and Toxicity Analysis. *Bioresour. Bioprocess.* **2014,** *1*, 1-10.
70. Medda, S.; Hajra, A.; Dey, U.; Bose, P.; Mondal, N.K. Biosynthesis of Silver Nanoparticles from Aloe Vera Leaf Extract and Antifungal Activity against *Rhizopus Sp.* and *Aspergillus Sp. Appl. Nanosci.* **2015,** *5*, 875-880.

16/8/19

RESERACH SCHOLAR
Nishat Bhatia.
Enrollment No: H 13057.
Ph.D Research Scholar (Chemistry).
Career Point University.
Hamirpur (H.P) – 176041.

SUPERVISOR
Dr. Rahul Sharma (Assistant Professor).
Department of Chemistry.
School of Basic and Applied Sciences.
Career Point University
Hamirpur (H.P) – 176041.